SUMMER SCHOLARSHIP REPORT

1.	**Project Title**	:	Understanding capacity of aerial seed dispersal in revegetation of abandoned farming areas in an agroecological landscape
2.	**Proposed Start Date**	:	2nd December 2019
	Proposed Cease Date	:	3rd March 2020
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1. Executive Summary:

- This report investigates the potential contribution of aerial seed dispersal on natural regeneration on abandoned cropping fields of cotton farms in the northern Murray-Darling Basin.
- Propagule traps were installed and monitored to investigate the abundance and composition of dispersing seeds in abandoned cropping fields and paired remnant vegetation patches.
- Species composition and abundance varied between land use histories. Remnant vegetation had a higher abundance of native species whilst abandoned cropping fields contained more exotic species.
- The distance to remnant vegetation had no significant influence on the abundance of seeds captured in abandoned cropping fields.
- There is potential for natural regeneration via aerial seedbanks in both land use histories.

2. Background:

Across the globe agricultural land abandonment is increasing due to socioeconomic and environmental drivers (Cramer et al., 2008). Simultaneously large-scale revegetation is urgently required to help halt biodiversity loss, sequester carbon and restore ecosystem services. Active restoration is a popular method of restoration, meaning the planting of tube stock or the addition of seeds. However, these methods are often costly and unsuccessful due to being so entirely reliant on human involvement. Natural regeneration is an alternative to active methods, it relies on environmental processes to facilitate regeneration (Dorrough et al., 2005). The natural regeneration method uses processes that naturally occur within environments such as regrowth. Natural regeneration is significantly more cost effective than active regeneration (Evans 2015). This allows it to be applied to large scale projects in a way that active methods cannot (Chazdon et al., 2016). There are many benefits of natural regeneration including a higher amount of species diversity and the preservation of localised genetic diversity (Kitzmiller et al., 1990). Aerial seedbanks are one means of natural regeneration. The seeds that comprise aerial seedbanks occur from dispersal by wind and flight through the air or stored within the canopy of surrounding vegetation. Aerially dispersed seeds allow species of plants to increase their chance of survival by entering new environments (Lamont et al., 2008). In Australia there is a large amount of agricultural land being abandoned due to no longer being viable, many of these occurring in semi-arid regions. Many of these areas are extremely vast and remote, meaning significant costs and effort could be incurred by active restoration projects. Natural regeneration offers an alternative to active methods.

3. Aims and Objectives:

This study focussed on the potential for natural regeneration via aerially dispersed seeds in semi-arid regions of Australia within different land use histories. An emphasis was placed on the relationship between assemblages of dispersed seeds and proximity to remnant vegetation. It was thought a higher abundance of species would arrive at a regenerating site when situated within or near remnant habitat. It is hoped that by better understanding seed dispersal composition new knowledge will be generated on the potential for naturally regenerating areas of semi-arid Australia with different land use histories.

4. Materials and Methods:

Study area

This study was conducted within the semi-arid regions of the northern Murray Darling Basin (MDB). Samples were collected from four major regions of the northern MBD; Bourke, Moree, Mungindi and St George. The climate in these regions is classified as hot, persistently dry grasslands (Walker et al., 1995).

The typical land-use in the regions is a mix of irrigated and dryland cropping, as well as livestock grazing. When the samples were collected for this study the region was experiencing one of the worst periods of drought in recorded history (MDBA 2020).

Field collection

The study locations were selected to represent areas with different land-use histories. The two different histories were abandoned cropping fields and remnant vegetation. Whilst the remnant areas are used for grazing, they have never been cultivated for cropping. Abandoned cropping fields are classified as areas that have once been cultivated for cropping but not within the past five years (*see table 1).*

The propagule traps in this experiment were artificial grass mats. The mats were placed at 72 locations throughout the locations of different land use history with 18 mats distributed. In each region, nine mats were positioned in remnant vegetation areas and the other nine in abandoned cropping fields with varied time since abandonment (*see table 1).*

Each mat was 0.5m width x 0.5m length, secured to the ground using tent pegs. A stake was placed in the ground so that the mats could be located at the end of the study period. Mats were left at all locations for six months between January and July 2019. Upon collections of the mats, it was found that five remnant mats were missing and 14 from abandoned cropping field sites. Collection was inhibited due to the stakes being unable to locate, this is likely due to weather events over the six-month period. In total 31 remnant site mats were collected and 22 from abandoned cropping fields. The seed mats were collected, placed into individual plastic bags and carefully transported back to facilities at Griffith University and stored.

Seedling emergence trials

Small plastic containers (172mm x 120mm x 50mm) were filled with two centimetres of vermiculite and then four centimetres of seed raising mix, and plant propagules from each seed mat was placed on top. The containers were labelled and then placed in the Griffith University glasshouse facility. The containers were rotated around the glass house to ensure equal amounts of sunlight and water. The seeds were watered every day in the afternoon, creating relatively damp conditions for the seeds. Damp conditions produce the highest abundance and diversity of seedlings from seedbanks (James 2006). The period of growth lasted twelve weeks, from the 8th of December to the 8th of March. The average temperature in the glasshouse for this period was 35.58 degrees Celsius. Over the course of this period as each seedling matured it was identified to species level where possible and recorded.

Data analysis

Exploratory analysis was performed on the dataset in the form of a bar graphs. These graphs assisted the direction of further analysis which involved ANOVA testing. Species abundance and richness were both compared across location, land use history and in relation to functional species groups. A logistic regression was used to test the relationship between distance to remnant vegetation and species abundance. All testing was performed through R Studio.

5. Results:

In total 760 seedlings were recorded in the experiment. 495 individuals were recorded in remnant vegetation seedbanks and 265 in the abandoned cropping field samples. Remnant samples comprised of 62.07% native species and 17.24% exotic. Abandoned cropping fields had 64% native species and 24% exotic, the remainder were unidentified species. The species composition of each land use type was unique. Two different species of trees were recorded, *Eucalyptus camaldulensis* and *Acacia stenophylla*.

Location	**Time since abandonment (years)**		
Bourke	40	9	9
Moree	7	20	33
Mungindi	10	20	5
St George	8	33	28

Table 1: Showing the times since land use abandonment at 'abandoned cropping field' sites.

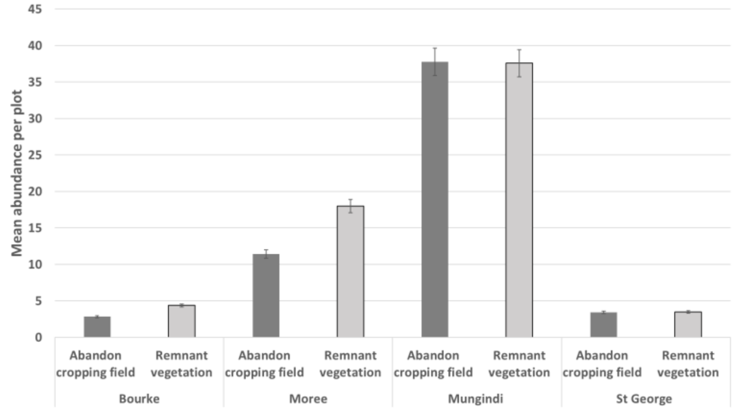

*Figure 1: This bar graph shows the mean **abundance** of species per plot within land-use history and location. There was no significant disparity between land use histories. There was some variation between locations, particularly with the Mungindi sites recording significantly higher abundance levels.*

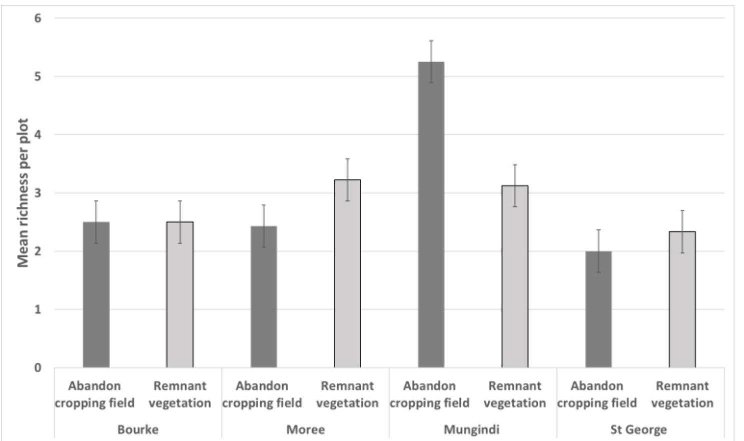

*Figure 2: This bar graph shows the mean **richness** of species per plot within land-use history and location. There was no significant disparity between the species richness recorded at any of the sites; except for abandoned cropping fields in Mungindi.*

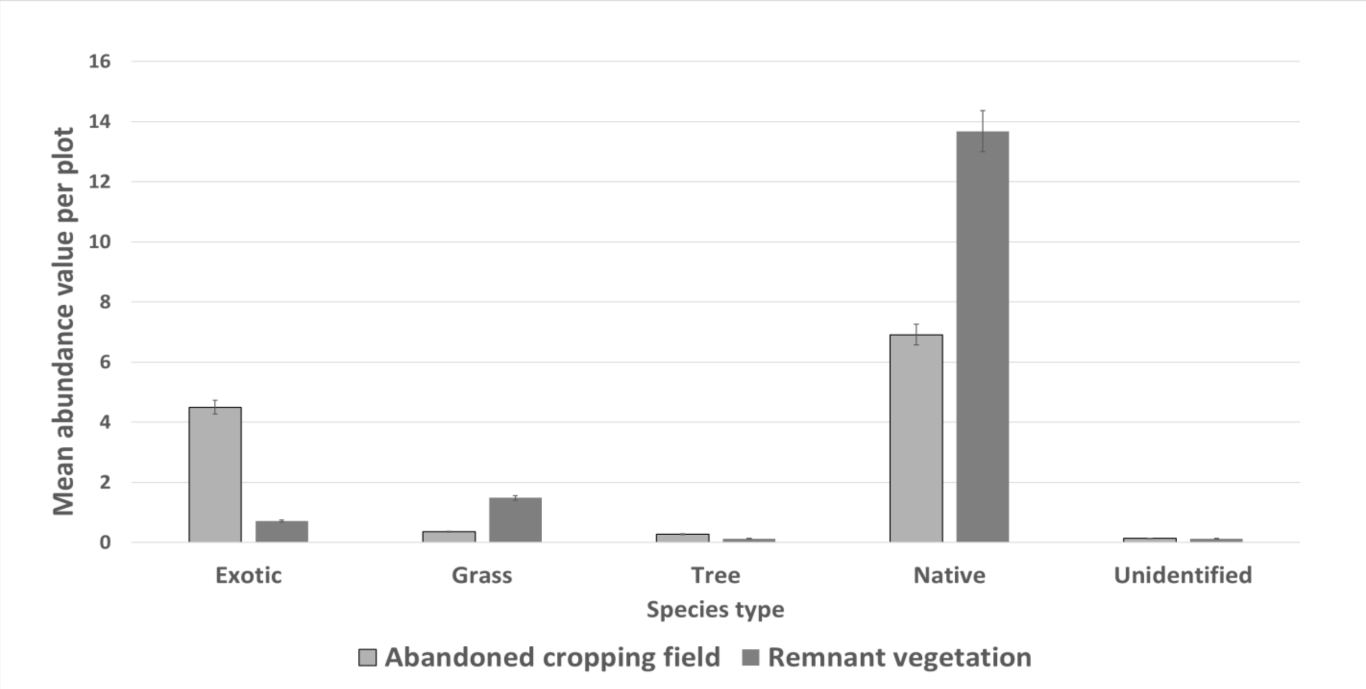

Figure 3: This bar graph shows the mean abundance of species in relation to their functional group and land use history. The most apparent differences were a higher abundance of native species at remnant sites, and a higher abundance of exotic species at abandoned cropping field sites.

Table 2: Logistic regression			
Response: Distance	DF	Adjusted R-square	P
	51	-0.002305	0.3525

Table 2: This table shows the results of logistic regression testing performed to investigate whether there was a relationship between distance to remnant vegetation and seed availability. The testing shows that there was no relationship between seed abundance and proximity to remnant vegetation.

6. Discussion and Conclusions:

This study has revealed many insights into the composition of aerially dispersed seeds in semi-arid environments. Through these insights much was learned about the potential for natural regeneration in semi-arid Australia, including abandoned cotton farms in the northern Murray-Darling Basin. The findings show that there is certainly potential for aerially dispersed seeds to contribute to the regeneration of Australian semi-arid areas with different land use histories.

Species composition

There were no major differences between the species abundances or richness recorded within locations. Demonstrating that aerial seeds can travel across environments independent of land use history, without being limited by any forms of physical barriers in the immediate environment. *Figure 1* and *Figure 2* revealed that there was a significant difference between the abundance and richness of species between different locations, suggesting that some environments have limited aerial seed dispersal while others do not. The compositions of aerially dispersed seeds differed across land use history; *Figure 3* shows this variation. There is a higher abundance of native and grass species in the remnant vegetation areas, and a higher abundance of exotic species in abandoned cropping field samples. This is due to the typical characteristics of remnant areas in this landscape. These areas are often comprised of open woodlands and grass plains. The presence of native species in established environments can reduce the richness and abundance of exotic species (Abella et al., 2012). The higher abundance of exotic species in abandoned cropping fields is due to the previous land use of the areas. Prolonged periods of disturbance promote the growth of many exotic species in Australian environments (Jauni et al., 2014). As these areas are formerly used for agriculture many exotic plants would have been planted deliberately as a source of livestock feed. Grazing can also contribute to the spread of exotic species (Kutt et al., 2010). This means that natural regeneration projects would wield different compositions of exotic and native species depending on the land use history. *Figure 3* also shows that both land use histories had tree species present within aerial their seedbanks. This is highly significant as trees can mature to become keystone elements of their environments (Manning et al., 2006). Keystone species are critical for the survival of many species within ecosystems, they are therefore critical to the success of natural regeneration (Stagol et al., 2012). For the abundance of aerial seedbanks to flourish naturally in Northern MDB semi-arid environments water is necessary. When water is added to aerial seedbanks they can thrive. Seed banks with more access to wet conditions present more diversity and abundance (James et al., 2006). It is likely that semi-arid environments in the northern MDB would require some form of hydrological event to naturally regenerate, either flooding or significant rainfall.

Proximity to remnant vegetation

No relationship was found between distance to remnant vegetation and seed availability (*see table 2).* It was originally thought that the aerial seedbanks in closer proximity to remnant vegetation would present a higher abundance due to seed availability. In this study seed availability was not limited by environmental barriers, nor distance from remnant vegetation. This is because seeds can travel long distances given the appropriate conditions (Horn et al., 2001). A lack of dense canopy may allow for seeds to disperse relatively uniformly across semi-arid environments. This finding means that there is potential to use aerial seedbanks for natural regeneration projects even when remnant vegetation is not in direct proximity.

Conclusion

This study has revealed that there is certainly potential for aerially dispersed seeds to be used for natural regeneration, independent of land use histories. The environmental factors at different locations are important considerations as there are significant disparities in species abundance between locations used in this study. For natural regeneration to occur it is likely that a hydrological event(s) would need to occur to stimulate the growth of species. The tree species present indicate the potential for keystone species to arise from aerial seedbanks. Additionally, proximity to remnant vegetation is not a barrier to the abundance of species present for natural regeneration.

7. Highlights:

- The species composition of the aerially dispersed seeds studied indicates potential for use in natural regeneration, with the assistance of environmental factors.
- There is no relationship between distance to remnant vegetation and species abundance.

8. Future Research:

As many dissemination processes are seasonal, sampling and growing all year-round would likely expand the dataset. During this study there was a significant period of drought occurring in the region, as the drought now has ended it would be interesting to assess the resulting changes to seedbanks. This research could be expanded as part of an Honours project.

9. Presentations and Public Relations:

It is intended that this paper will be appropriately altered for future publication.

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